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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 10/705,224
Filing Date: November 12, 2003
Appellant(s): FINK ET AL.

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GROUP 1700

Jeffrey D. Karceski
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 12/27/2006 appealing from the Office action mailed 3/7/2006.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings, which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is substantially correct. The changes are as follows: Claim 2 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Hiroyuki (JP 2002-252209) or Tomoyasu et al (US 6,264,788) or Li et al (US

6,506,685) or Ludviksson et al (US 2005/0041238) (known henceforth as the primary prior art) in view of Kanno et al (US 6,646,233).

Appellant did not include all the primary prior art recited in the rejection.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

US Patent/Patent Publications

Number	Inventor	Date Published
6,506,685	Li et al	01-2003
6,646,233	Kanno et al	11-2003
2005/0041238	Ludviksson et al	02-2005
6,264,788	Tomoyasu et al	07-2001

Foreign Patent

Country-Number	Inventor	Date Published
JP-2002252209	Hiroyuki	09-2001

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

A. Claims 1,3-5, 9-14, and 16 are rejected under 35 USC §102 (b) as being anticipated by Hiroyuki (JP 2002-252209, using the English Translation).

Regarding claims 1 and 16: Hiroyuki teaches a plasma etching chamber comprising a substrate holder 8, a baffle plate 12 with at lease one passageway, and a centering ring (insulating ring) 13, see Fig. 1.

Regarding claims 3-5: The centering ring 13 comprises a centering feature to center the baffle plate onto the ring see Fig.1. The centering feature of the centering ring is a centering edge, see Fig.1 The baffle plate has a mating feature (an edge portion of the plate)that is coupled to the centering feature.

Regarding claims 9-13: Hiroyuki teaches that the baffle plate has a protective barrier wherein this coating is formed by thermal spraying, [0005]. Though, Hiroyuki does teach the coating is sprayed, it is noted that the method of coating is also a product-by-process limitation and does not have patentable weight as the coating of Hiroyuki could have been formed by any of the methods listed in claim 11, [0028]. Yttria (Y2O3) and YF3 are listed as materials of construction, see [0005] and [0006].

Regarding claim 14: The one or more passageways of the baffle 12 are orifices see Fig. 1.

B. Claims 1,6-8, and 14-16 were rejected under 35 USC § 102(b) as being anticipated by Tomoyasu et al (US 6,264,788).

Regarding claims 1 and 16: Tomoyasu et al teaches a plasma apparatus comprising a baffle plate 326 assembly surrounding a substrate holder (susceptor) 305 in a plasma processing system comprising: a centering ring 325/327 coupled to the substrate holder 305 wherein a portion of the ring extends radially outside a periphery of the holder and a the baffle plate has a plurality of

gas passageways, see Fig. 8. The baffle plate is configured to be centered within the plasma processing system by coupling (note an integrated member anticipates coupling) the plate to the portion of the ring that is outside the periphery of the holder, see col. 11 lines 5-47.

Regarding claim 6: The baffle plate features a mating feature which is a centering edge see Fig. 8, see also col.12 lines 47-50. Note how element 325 mates with 32L.

Regarding claim 7: The ring is made of aluminum (Al) according to col. 11 lines 5-19.

Regarding claim 8: Col.12 lines 47-65 teaches that the baffle plate is made of Al.

Regarding claim 14: A plurality of holes (orifices) are in the baffle plate see col. 11 lines 5-19.

Regarding claim 15: The size of these holes changes according to col.12 lines 26-67.

C. Claims 1,8, and 14-16 were rejected under 35 USC § 102(e) as being anticipated by Li et al (US 6,506,685).

Regarding claims 1 and 16: Li et al teaches a perforated plasma confinement ring in plasma reactors. The apparatus comprises a baffle plate 222 assembly surrounding a substrate holder in a plasma processing system comprising: a centering ring 216 coupled to the substrate holder 210 wherein portion of the ring extends radially outside a periphery of the holder and the baffle plate has a plurality of gas passageways. The baffle plate is configured to be centered within the plasma processing system by coupling the plate to the portion of the ring that is outside the periphery of the holder. See Fig. 3 and col. 5 and 6.

Regarding claim 8: SiC is used to construct the baffle plate according to col. 6 lines 8-27.

Regarding claims 14 and 15: The baffle plate feature a plurality of perforations that vary in size and are slots according to col.6 lines 41-65.

D. Claims 1,7-13, 16, and 17 were rejected under 35 USC § 102(e) as being anticipated by Ludviksson et al (US 2005/0041238).

Regarding claims 1 and 16: Luvdiksson et al teaches a substrate holder 30, a centering ring 61 (62), and baffle plate 64. Fig. 1 illustrates that the centering ring extends beyond the edge of the holder.

Regarding claims 7 and 8: The baffle plate is made of Al according to [0057].

Regarding claims 9-13:[0081] and [0082] teaches that a coating is used on the baffle plate. The materials of construction are listed in [0081], spray coating is amongst the methods used to perform the coating of the barrier layer. It is noted that the method of coating is also a product-by-process limitation and does not have patentable weight as the coating of Hiroyuki could have been formed by any of the methods by Luvdiksson et al.

Regarding claim 17: Baffle plates and centering rings are listed amongst the consumable replaceable components in the chamber, see [0056] and [0057].

E. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hiroyuki (JP 2002-252209) or Tomoyasu et al (US 6,264,788) or Li et al (US 6,506,685) or Ludviksson et al (US 2005/0041238) (known henceforth as the *primary prior art*) in view of Kanno et al (US 6,646,233).

The teachings of the primary prior art were discussed above.

All fail to teach a fastener used to couple the centering ring to the holder.

Kanno teaches a plasma reactor with a holder 14 and a ring 75. Fig. 2 illustrates bolt 36(fastener) to couple the ring to the substrate holder. The motivation to provide the fastener of

Kanno to couple the holder and rings of the *primary prior art* is that these bolts are suitable means of fixing the ring to the holder according to col.8 lines 13-23. Thus, it would have been obvious for one of ordinary skill in the art at the time of the claimed invention to provide the bolts of Kanno in the primary prior art to fix the rings to the substrate holders in these plasma apparatus.

(10) Response to Argument

A. Appellant argues that the prior art of Hiroyuki does not teach a centering ring. The examiner's interpretation of a centering ring is a ring that is configured to be coupled to the substrate holder wherein a portion of the ring extends radially outside a periphery of the substrate holder. The insulating ring of Hiroyuki is configured to be a centering ring in that the ring is located in the center of the chamber and maintains the position of the baffle plate in the process chamber and that the centering ring ensures that the baffle plate is symmetric with the holder.

B. Appellant argues that since the baffle plate 326 of Tomoyasu is integral with the centering ring 325, the centering ring is not coupled to the substrate holder. Note that in Fig.8 the centering ring contacts the holder. The language of claim 1 recites that the baffle plate is centered within the plasma process system by coupling the baffle plate to a portion of the centering ring. It is the examiner's position that integration of the baffle plate and the centering ring anticipates coupling.

C. Appellant argues that the prior art of Li et al fails to teach a centering ring and that Li et al fails to teach that the centering ring is coupled to the substrate holder where at least a portion of the centering ring extends radially outside the periphery of the substrate holder. The

examiner's interpretation of a centering ring is a ring that is configured to be coupled to the substrate holder wherein a portion of the ring extends radially outside a periphery of the substrate holder. The insulating ring of Li et al is configured to be a centering ring in that the ring is located in the center of the chamber and maintains the position of the baffle plate in the process chamber and that the centering ring ensures that the baffle plate is symmetric with the holder, see Fig.3. The examiner also notes that the sentence adjoining columns 5 and 6 recites that the ring 222 (baffle plate) has an inner periphery (its mating feature) that is abutted to the outer periphery (its centering feature) of a focus ring/centering 216.

D. Appellant argues that the prior art of Ludvickson et al fails to teach a centering ring and further fails to teach that the centering ring is coupled to a baffle or that the ring extends radially outside a periphery of the substrate holder. See Fig.1 and [0047] wherein the substrate holder is coupled to ring 60 and ring 62. Furthermore, the baffle plate 64 is extended about the periphery of the holder 30.

E. Appellant argues that there is not motivation to combine the primary prior art of Hiroyuki (JP 2002-252209) or Tomoyasu et al (US 6,264,788) or Li et al (US 6,506,685) or Ludviksson et al (US 2005/0041238) (known henceforth as the *primary prior art*)with Kanno et al (US 6,646,233). Note each of the *primary prior art* teaches the coupling of a centering ring, substrate holder, and baffle plate with each other primarily through abutting or integration. All fail to teach coupling the centering ring to the holder through using fasteners. Using fasteners to enhance coupling of components is conventional in the field of semiconductor manufacturing. Fig. 2 of Kanno features a water cooling jacket 14 within stage (substrate holder) 2 coupled to a ring 75 (susceptor) via a fastener 36 (bolt). See also col. 8 lines 13-23. The motivation to

combine the *primary prior art* with Kanno is that Kanno shows that bolts (type of fasteners) are used to couple components in the harsh semiconductor processing environment.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Examiner Sylvia R. MacArthur

Conferees:

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Jennifer ~~Kolb-Michner~~ Michener
QAS

PTO 07-3259

CC=JP DATE=20020906 KIND=A
PN=14252209

PLASMA ETCHING APPARATUS
[Purazuma Etchingu Sochi]

Nobuyuki Nagayama, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. March 2007

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INVENTORS	(72):	NAGAYAMA, NOBUYUKI, MITSUHASHI, KOJI NAKAYAMA, HIROYUKI
APPLICANT	(71):	TOKYO ELECTRON CO., LTD.
TITLE	(54):	PLASMA ETCHING APPARATUS
FOREIGN TITLE	[54A]:	PURAZUMA ETCHINGU SOCHI

[Claims] /2*

[Claim 1] A plasma etching apparatus that dry-etches a target article so as to microfabricate the surface of said target article,

said apparatus being characterized by the fact that, at a minimum, the surfaces of the plasma resistant components provided in the processing chamber are formed from yttrium fluoride.

[Claim 2] The plasma etching apparatus stated in Claim 1, wherein the aforesaid plasma components are formed by thermal-spraying yttrium fluoride onto the surface of a raw material.

[Claim 3] The plasma etching apparatus stated in Claim 1, wherein the aforesaid plasma components are formed from a sintered compact of yttrium fluoride.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention pertains to a plasma etching apparatus. More specifically, it pertains to a plasma etching apparatus that dry-etches target articles, such as semiconductor wafers and so forth, so as to microfabricate said target articles.

[0002]

[Prior Art] Heretofore, in semiconductor fabrication processes, plasma etching apparatuses have been used to microfabricate target articles, such as semiconductor wafers and so forth.

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* Numbers in the margin indicate pagination in the foreign text.

[0003] More specifically, with this type of plasma etching apparatus, inside its airtight processing chamber are installed an upper electrode and lower electrode in such a manner as to face each other, and also provided are plasma resistant components around the upper electrode and lower electrode. High-frequency power is applied to the lower electrode, on which is placed a target article, and to the upper electrode so as to generate a glow discharge between the lower electrode and upper electrode, and, in tandem with this, a processing gas is introduced into the processing chamber, thereby trapping the aforesaid processing gas between the upper electrode and lower electrode and generating dense plasma. With said dense plasma, etching is performed on the target article. As the processing gas, CF (fluorocarbon) gases have been widely used.

[0004] As the material used for the aforesaid plasma resistant components, Al that has an oxidized surface (aluminum alumite) and sintered ceramics of Al_2O_3 (alumina) have been used heretofore. However, this type of material containing an Al component reacts with the aforesaid CF gases and generates AlF_3 (aluminum fluoride), and this AlF_3 becomes solid fine particles and scatters inside the processing chamber; as a result, said solid fine particles attach firmly to the surface of the aforesaid target article, thus presenting the problem of what is called Al contamination.

[0005] Accordingly, Y_2O_3 sprayed materials, which are prepared by the thermal spraying of yttrium oxide (Y_2O_3), which has excellent

plasma resistance, onto the surface of materials, such as Al and the like, have started to be used in recent years.

[0006]

[Problems that the Invention Intends to Solve] However, even if a Y_2O_3 sprayed material is employed for the plasma resistant components in the aforesaid plasma etching apparatus, because Y_2O_3 reacts with a CF gas, the surface layer is fluoridated and forms yttrium fluoride (YF_3), and this YF_3 becomes solid fine particles and scatters inside the plasma ambience. That is, when a Y_2O_3 sprayed material is employed for the plasma resistant components, the Al contamination of the target article can be circumvented, but, on the other hand, YF_3, the reaction product with a CF gas, becomes solid fine particles and scatters inside the plasma ambience; as a result, the surface of the plasma resistant components, that is, the Y_2O_3 sprayed material, is consumed, thus raising the problem that said plasma resistant components wear off easily.

[0007] The present invention was achieved in view of these problems, and it intends to provide a plasma etching apparatus that is equipped with plasma resistant components that have further improved durability.

[0008]

[Means for Solving the Problems] In order to improve the durability of the plasma resistant components, the formation of solid fine particles that could scatter from said plasma resistant

components must be inhibited, and, to achieve this, it is necessary to select a material type that causes scarcely any chemical reaction with the processing gas, a CF gas and, thus, is chemically stable with a CF gas.

[0009] From this standpoint, it is conceivable to select, for example, AlF_3 proper as the material for the plasma resistant components. That is, as described in the foregoing, because AlF_3 is a reaction product of a CF gas with aluminum alumite or a sintered compact of Al_2O_3, it is considered to be a substance that is chemically more stable than aluminum alumite or a sintered compact of Al_2O_3. Therefore, the use of AlF_3 proper directly as the plasma resistant components can supposedly decrease solid fine particles effectively.

[0010] However, the results of the experiment conducted by the present inventors revealed that AlF_3 has a high vapor pressure, and the vapor pressure of AlF_3 could approach the pressure inside the processing chamber depending on the operation conditions of the plasma etching apparatus; as a consequence, AlF_3 could detach in the form of solid fine particles and easily scatter in the plasma ambience.

[0011] Accordingly, the present inventors conducted intensive research to obtain a material that had a vapor pressure lower than that of AlF_3 and that was also chemically stable with CF gases and, as a result, learned that YF_3 met these requirements, and the use of said YF_3 as the material for the plasma resistant components could inhibit

the fluoridating reaction at the surface layer and also reduce the scattering of fluorides in the plasma ambience, thereby making it possible to improve the durability of the plasma resistant components.

[0012] The present invention was achieved based on this finding, and the plasma etching apparatus pertaining to the present invention is characterized by the fact that, at a minimum, the surfaces of the plasma resistant components installed inside the processing chamber are formed from yttrium fluoride.

[0013] With the aforesaid configuration, because the plasma resistant components are formed from yttrium fluoride (YF_3), the formation of solid fine particles is inhibited, and the degree of wear of the plasma resistant components inside the processing chamber can be reduced; consequently, their durability can be improved. /3

[0014] According to the present invention, the plasma resistant components may be formed by the thermal-spraying of yttrium fluoride on the surface of a raw material, and it is also desirable to form the aforesaid plasma resistant components from a sintered compact of yttrium fluoride.

[0015]

[Preferred Embodiments] The following explains the preferred embodiments of the present invention.

[0016] Fig. 1 is a structural drawing of the interior of the plasma etching apparatus pertaining to the present invention, and inside the main body (1) of the apparatus is provided a lower

electrode (2) that is formed from a conductive material. On the upper surface of said lower electrode (2) is mounted an electrostatic chuck (4) for attaching and holding a semiconductor wafer (3), which is an article to be processed, and on the lower side of said lower electrode (2) is provided a hoisting shaft (5) that can move up and down in the direction of arrow A, said hoisting shaft (5) supporting the lower electrode (2). The hoisting shaft (5) is also connected to a high-frequency power source (7) via a matching box (6).

[0017] The bottom surface and side surface of the aforesaid lower electrode (5 [sic]) are protected by an electrode protecting component (8), and the side surface and bottom surface of said electrode protecting component (8) are covered with a conductive component (9). Furthermore, between the conductive component (9) and the bottom of the main body (1) of the apparatus is seated a retractable bellows (10) made from a conductive material, such as stainless steel or the like. On the underside of the electrode protecting component (8) is provided a tubular component (11) that is composed of a conductive material, such as oxidized Al or the like, and the aforesaid hoisting shaft (5) is inserted through the aforesaid tubular component (11).

[0018] To the side surface of the electrode protecting component (8) is firmly fixed a baffle plate (12) in the shape of a collar, and an insulation ring (13) is placed between the edge of the electrode protecting component (8) and the side surface of the electrostatic chuck (4). From the underside of the baffle plate (12), a first

bellows cover (14) is suspended, and a second bellows cover (15) is provided to stand up from the bottom of the apparatus main body (1), partially overlapping with the first bellows cover (14).

[0019] At the upper part of the apparatus main body (1) is provided an upper electrode (16) that is formed from a conductive material, facing the aforesaid lower electrode (2). Said upper electrode (16) has a large number of gas discharge holes (17) that run through it, and a processing gas that contains a CF gas is supplied from a gas supply port (18) provided on the upper surface of the apparatus main body (1) to the processing chamber (22) through the gas discharge holes (17). More specifically, the gas supply port (18) is connected to a gas supply source (21) through a flow-rate regulating valve (19) and an open/close valve (20), and the processing gas from the gas supply source (21) is supplied to the gas supply port (18) through the open/close valve (20) and the flow-rate regulating valve (19). The processing gas is discharged from the gas discharge holes (17) and introduced into the processing chamber (22).

[0020] At the bottom of the apparatus main body (1), a vent (23) that runs through it is formed, and the vent (23) is connected to a vacuum pump (24). Furthermore, at the lower portion of the side surface of the apparatus main body (1) is provided a target-article transporting port (25), and it is used to carry in and out a semiconductor wafer (3).

[0021] At the periphery of the apparatus main body (1), a permanent magnet (26) is placed so as to generate a horizontal magnetic field in relation to the target article, that is, a semiconductor wafer (3).

[0022] With the plasma etching apparatus thus configured, after the hoisting shaft (5) is moved in the direction of arrow A by a driving mechanism that is not illustrated, thereby adjusting the position of the semiconductor wafer (3), said hoisting shaft (5) functions as a power-feeding rod, and, upon application of high-frequency power of, for example, 27.12 MHz, from the high-frequency power source (7) to the lower electrode (2), a glow discharge occurs, thereby forming a transverse magnetic field, in which the electric field and magnetic field intersect at right angles.

[0023] Then, the processing chamber (22) is vacuumed by the vacuum pump (24) to form a given vacuum atmosphere, and the processing gas from the gas supply source (21) is introduced into the processing chamber (22), upon which point said gas is formed into plasma, and desired microfabrication is performed on the masked semiconductor wafer (3).

[0024] Therefore, in the present embodiment, the insulation ring (13), electrode protecting component (8), baffle plate (12), first and second bellows covers (14, 15), and so forth, which are components that are required to have plasma resistance (plasma resistant components), are formed from YF_3.

[0025] That is, in order to reduce the degree of wear of the plasma resistant components and thereby to improve their durability, the formation of solid fine particles that scatter from the plasma resistant components must be inhibited. For this purpose, it is necessary to select a material that causes scarcely any chemical reaction with the processing gas, that is, a CF gas, as the material for the plasma resistant components.

[0026] From this standpoint, it is conceivable to select, for example, AlF_3 proper as the material for the plasma resistant components. Heretofore, as the plasma resistant components, aluminum alumite or a sintered compact of Al_2O_3 has been used, but aluminum alumite and a sintered compact of Al_2O_3 react with CF gases and produce AlF_3. That is, because AlF_3 is a reaction product of a CF gas and aluminum alumite or a sintered compact of Al_2O_3, it is considered to be a substance that is chemically more stable than aluminum alumite or sintered Al_2O_3 with CF gases; therefore, the use of AlF_3 proper directly as the plasma resistant components can supposedly decrease solid fine particles effectively.

[0027] However, the results of the experiment conducted by the present inventors revealed that AlF_3 had a high vapor pressure, and the vapor pressure of AlF_3 could approach the pressure inside the processing chamber depending on the operation conditions of the plasma etching apparatus; as a consequence, AlF_3 could detach in the form of solid fine particles and easily scatter in the plasma ambience.

[0028] Meanwhile, like AlF_3, YF_3 is also a product formed by the reaction between Y_2O_3 and a CF gas when a Y_2O_3 sprayed material is used for the plasma resistant components and is, therefore, chemically more stable than Y_2O_3, and it was learned that YF_3 has a lower vapor pressure than AlF_3 and, consequently, its pressure difference from the pressure inside the processing chamber is greater than that of AlF_3; as a consequence, its crystal particles do not detach easily from the surface layer, thus inhibiting the scattering of solid fine particles inside the plasma ambience. /4

[0029] Table 1 shows the vapor pressures of YF_3 and AlF_3 at room temperature (20 °C), 100 °C, and 200 °C.

[0030]

[Table 1]

Temperature / Material Type	Room Temperature (20 °C)	100 °C	200 °C
YF_3	1.3×10^{-6}	2.1×10^{-5}	3.2×10^{-3}
AlF_3	1.6×10^{-4}	9.3×10^{-4}	2.0×10^{-2}

Note) The unit is Pascal (Pa).

[0031] As is evident from this Table 1, the vapor pressure of AlF_3 is higher than the vapor pressure of YF_3, and it can approach the pressure of the processing chamber (22) (4 to 5×10^{-2} Pa) under some operation conditions. As a result, AlF_3 becomes easily detached and scattered. In other words, because the vapor pressure of YF_3 is lower than the vapor pressure of AlF_3 and has a greater pressure difference from the pressure of the processing chamber (22), solid particle formation from YF_3 is suppressed more than in the case of AlF_3; as a

result, the scattering of solid fine particles in the plasma ambience can be reduced.

[0032] Accordingly, in the present embodiment, YF_3, which has a lower vapor pressure than AlF_3 and which is more stable chemically than Y_2O_3, is used as the material for the plasma resistant components so as to prevent the wear of the plasma resistant components as much as possible and thereby to improve their durability.

[0033] As shown in the foregoing, because the plasma resistant components are formed from YF_3 in the present embodiment, the formation of solid fine particles can be reduced, and the degree of wear of the plasma resistant components can be further decreased, thus making it possible to improve their durability further.

[0034] Incidentally, the present invention is not limited to or restricted by the aforesaid embodiment. As long as the surface layer, at the least, of the aforesaid plasma resistant components is formed from YF_3, the formation of solid fine particles in the plasma ambience can be inhibited, and the desired objective can be achieved. Therefore, the plasma resistant components may be YF_3 sprayed products that are prepared by the thermal spraying of YF_3 on the surface of a material, such as Al or the like, or may be formed from a sintered compact of YF_3.

[0035] In the aforesaid embodiment, the plasma etching apparatus of the magnetic-field-assisted type, in which a permanent magnet (26) is provided on the periphery of the apparatus main body (1), is used

as an example in explaining the present invention. However, the present invention can, of course, be applied to other types--for example, to a plasma etching apparatus of the ion-assisted type that, instead of providing a permanent magnet (26), applies high-frequency power to both the upper electrode and lower electrode so as to generate plasma.

[0036]

[Working Examples] The following explains working examples of the present invention in more concrete terms.

[0037] [First Working Example] Using, as test pieces, $Y_2Al_5O_{12}$ (Yttrium-Aluminum-Garnet, hereinafter referred to as "YAG") and a sintered compact of Si_3N_4 (hereinafter simply referred to as "Si_3N_4") to which Y (Yttrium) was added as the sintering additive, the present inventors supplied a CF_4 gas into the processing chamber under the following conditions: 1400 W high-frequency power and 5.3 Pa (4.0×10^{-2} Torr) processing-chamber internal pressure and exposed the aforesaid test pieces to plasma. They examined the surface compositions before and after the plasma exposure with X-ray photoelectron spectroscopy.

[0038] Table 2 shows the compositional ratio of the elements at the surface of YAG before and after the plasma exposure, and Table 3 shows the compositional ratio of the elements at the surface of Si_3N_4 before and after the plasma exposure

[0039]

[Table 2]

Elements	Composition (%)	
	Before Plasma Exposure	After Plasma Exposure
Y	12	20
Al	16	12
F	2	47

[0040]

[Table 3]

Elements	Composition (%)	
	Before Plasma Exposure	After Plasma Exposure
Y	2	8
F	8	46

[0041] As is evident from Table 2, when compared before and after the plasma exposure, the Al components decreased from 16 % to 12 %, and the Y component increased from 12 % to 20 % and the F component from 2 to 47 %.

[0042] That is, AlF_3 had a higher vapor pressure than YF_3, thus having a smaller pressure difference from the internal pressure of the processing chamber; as a result, AlF_3 at the surface layer became solid fine particles and scattered, thus causing the decrease of the Al component.

[0043] On the other hand, because YF_3 had a lower vapor pressure compared with AlF_3 and had a sufficient pressure difference from the internal pressure of the processing chamber, YF_3 of the surface layer remained, without scattering in the form of solid fine particles; as a consequence, the Y component and F component increased after the plasma exposure.

[0044] The Y component also increased in Table 3 from 2 % to 8 % after the plasma exposure, and the F component also increased from 8 % to 46 %, thus indicating that YF_3 remained, without detaching from the surface layer of the test piece. /5

[0045] That is, it was confirmed that there was a sufficient pressure difference between the vapor pressure of YF_3 and the pressure of the processing chamber, and YF_3 remained at the surface layer of the test piece, without scattering in the plasma ambience in the form of solid fine particles.

[0046] [Second Working Example] The present inventors prepared test pieces that were 20 mm long, 20 mm wide, and 2 mm thick from three kinds of materials: YF_3, Y_2O_3, and SiO_2. As shown in Fig. 2, the periphery (30) of each test piece was masked with a polyimide film (trade name "Kapton", a product of DuPont Co.), and an exposure area that was 10 mm long and 10 mm wide was formed at the center (31). Each test piece was exposed to plasma under the following discharge conditions, and the consumed amounts in the X-axis direction and Y-axis direction were measured with a surface roughness tester.

[Discharge Conditions]

High frequency power: 1400 W

Power source frequency: 27.12 MHz

Processing-chamber pressure: 5.32 Pa (40 mTorr)

Reaction gas type: $CF_4/Ar/O_2$

Operation duration: 20 hours

Table 4 shows the measurement results, and Fig. 3 is a bar chart that indicates the average consumed amount of each type of test piece.

[0047]

[Table 4]

		Material	Consumed Amount (μm)		
			X-axis direction	Y-axis direction	Average
Working Example		YF_3	31	33	32
Comparative Example	1	Y_2O_3	38	32	34
	2	SiO_2	310	302	306

[0048] As is evident from this Table 4 and Fig. 3, SiO_2 had a large consumed amount due to its poor plasma resistance. In contrast, YF_3 had plasma resistance that was comparable or superior to Y_2O_3, which is said to have excellent plasma resistance, and also had a small wear amount; thus, it was confirmed to have excellent durability.

[0049]

[Effects of the Invention] As explained in the foregoing, the plasma etching apparatus of the present invention is a plasma etching apparatus that dry-etches a target article so as to microfabricate the surface of said target article, and, at a minimum, the surfaces of the plasma resistant components provided in the apparatus main body are formed from yttrium fluoride; therefore, the surfaces of the plasma resistant components are chemically stable with the processing gas (a CF gas), and it becomes possible to inhibit the scattering of solid fine particles and to reduce the wear of the plasma resistant components, thus improving their durability.

[0050] The aforesaid plasma resistant components may be formed by the thermal spraying of yttrium fluoride onto the surface of a raw material or may be formed from a sintered compact of yttrium fluoride, and, in either case, the aforesaid effects can be easily obtained.

[Brief Explanation of the Drawing]

[Fig. 1] A structural drawing that illustrates the interior of one embodiment of the plasma etching apparatus pertaining to the present invention.

[Fig. 2] A drawing for explaining the method for determining consumed amounts in the working example of the present invention.

[Fig. 3] A bar chart that shows the consumed amount of the working example of the present invention together with those of the comparative examples.

[Explanation of Reference Numerals]

3 semiconductor wafer (target article)

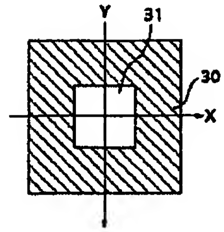
12 baffle plate (a plasma resistant component)

13 insulation ring (a plasma resistant component)

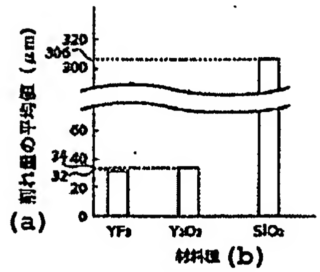
14 first bellows cover (a plasma resistant component)

15 second bellows cover (a plasma resistant component)

[FIG. 2]



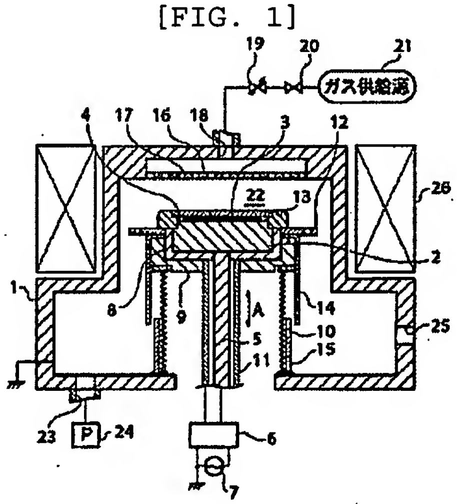
[FIG. 3]



Key: a) average of consumed amounts; b) material type.

/6

[FIG. 1]



Key: 21) gas supply source.